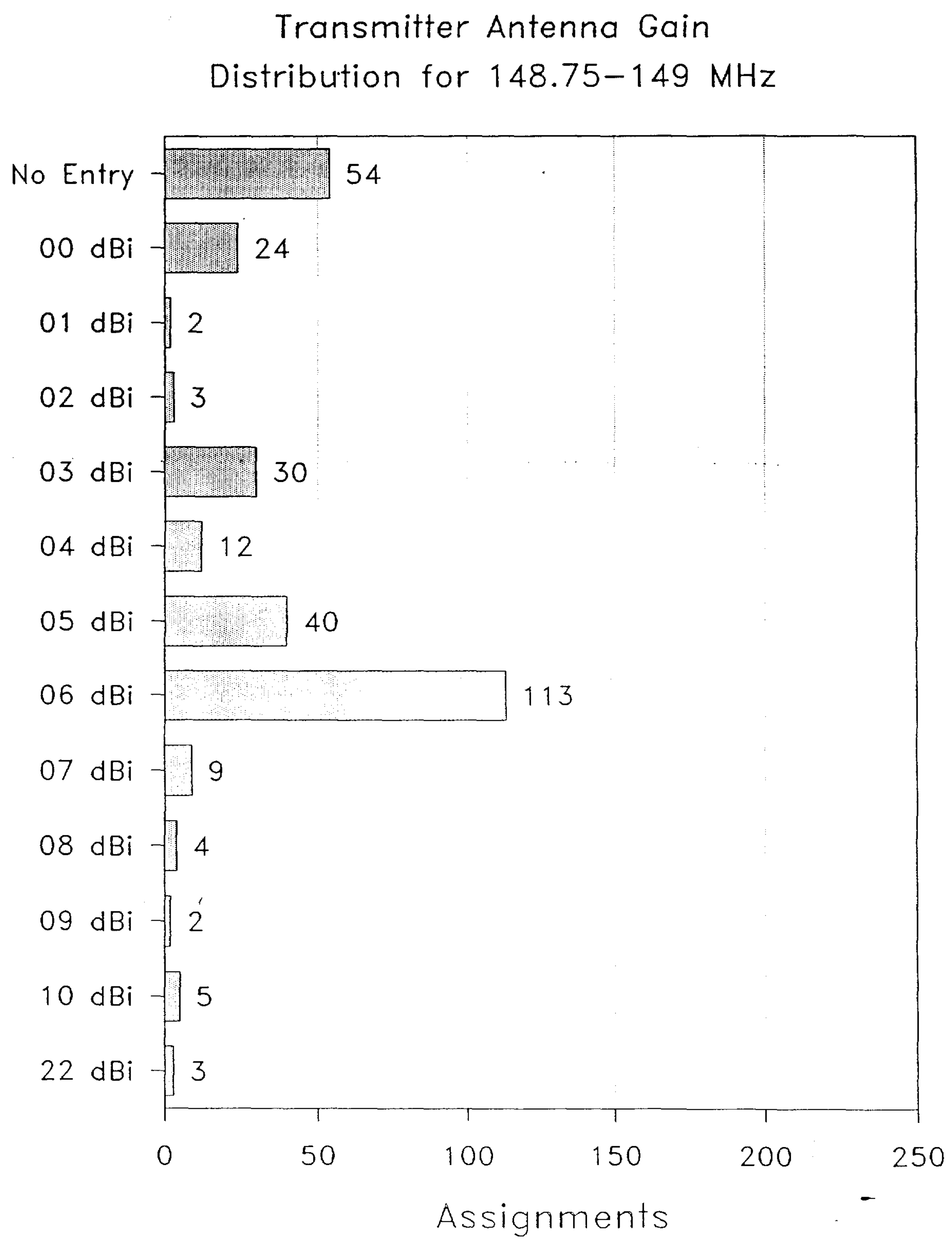
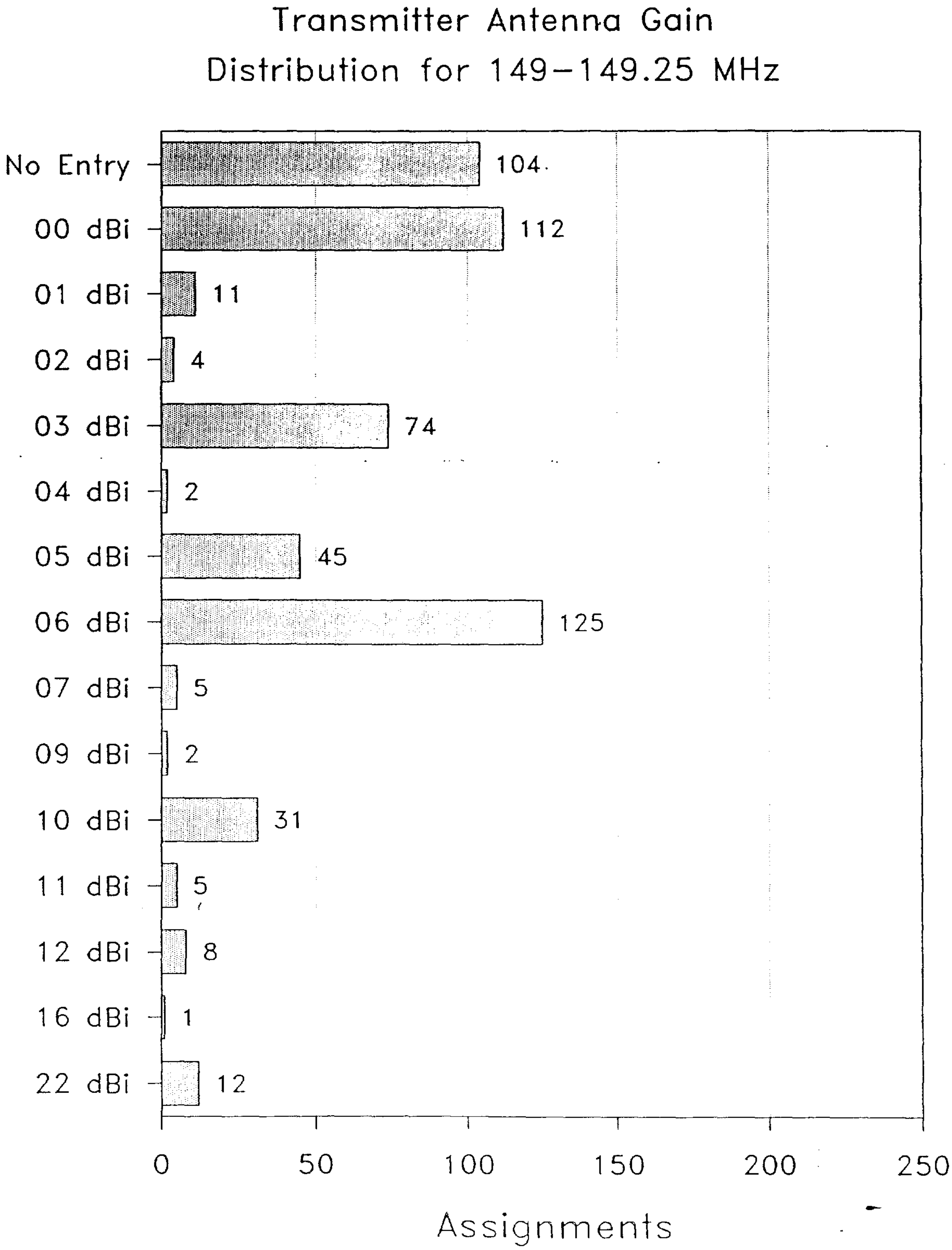
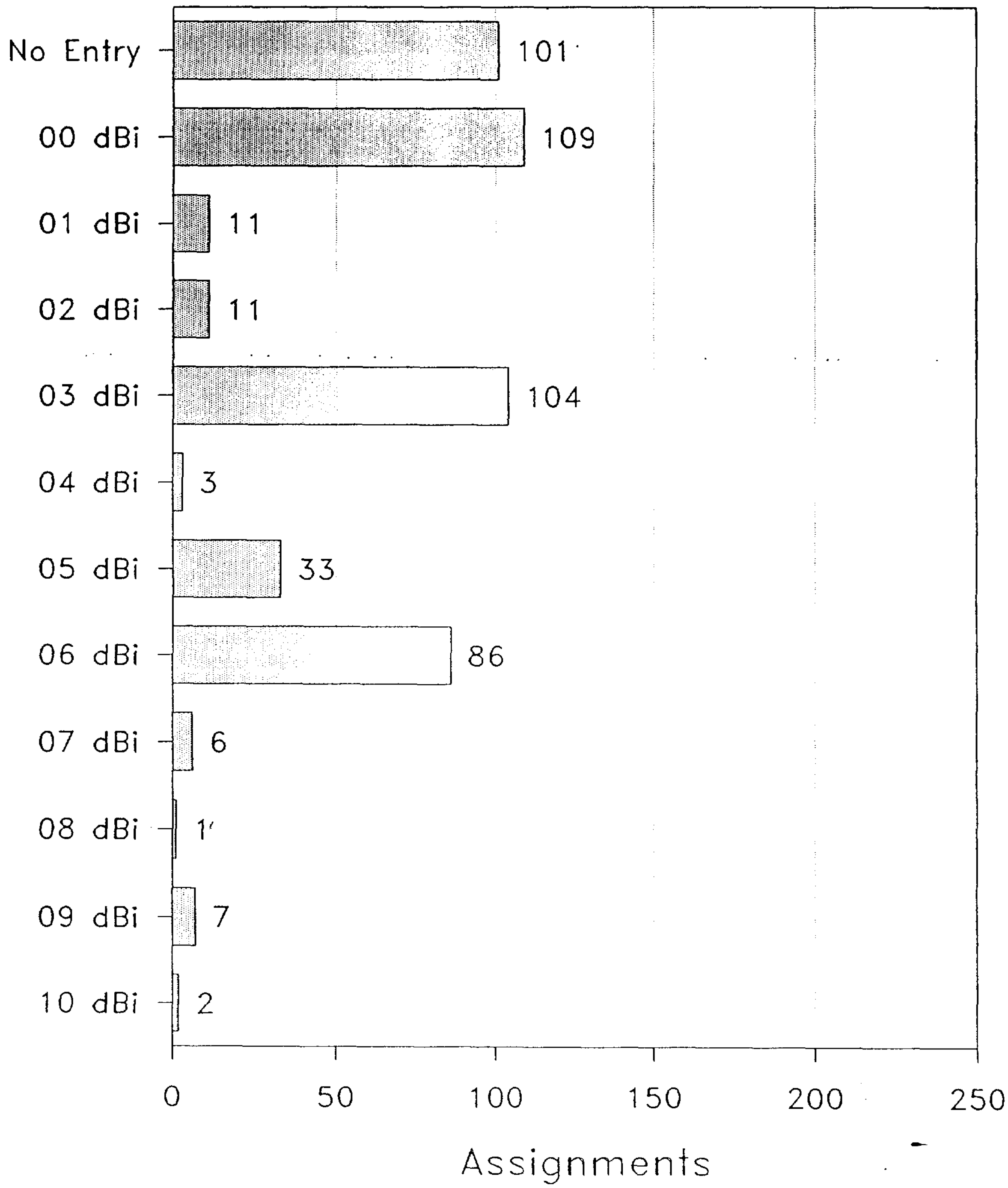
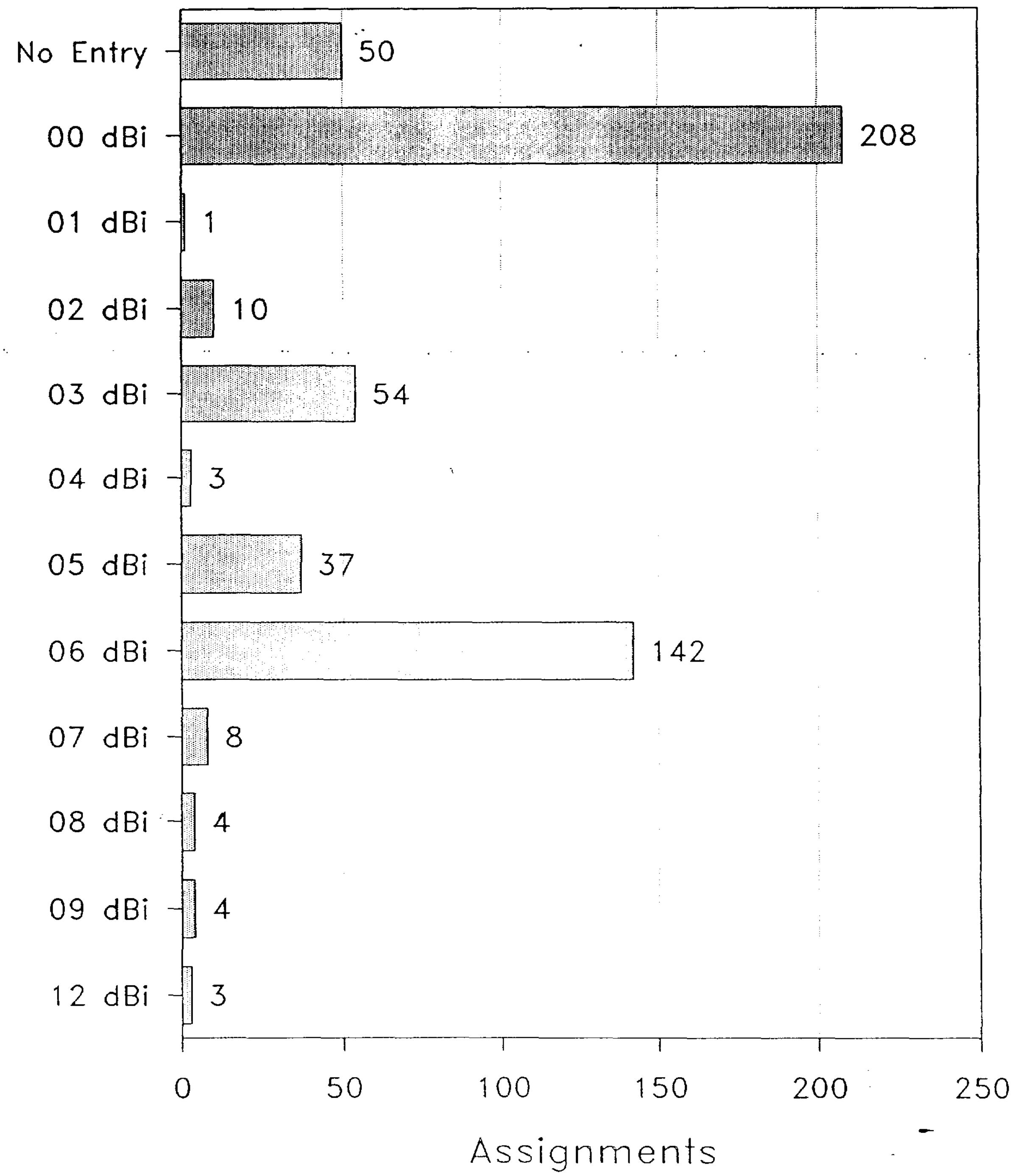

Transmitter Antenna Gain
Distribution for 148.75-149 MHz
No Entry
00 dBi
01 dBi
02 dBi
03 dBi
04 dBi
05 dBi
06 dBi
07 dBi
08 dBi
09 dBi
10 dBi
22 dBi
54
24
2
3
30
12
40
113
9
4
2
5
3
0
50
100
150
200
250
Assignments

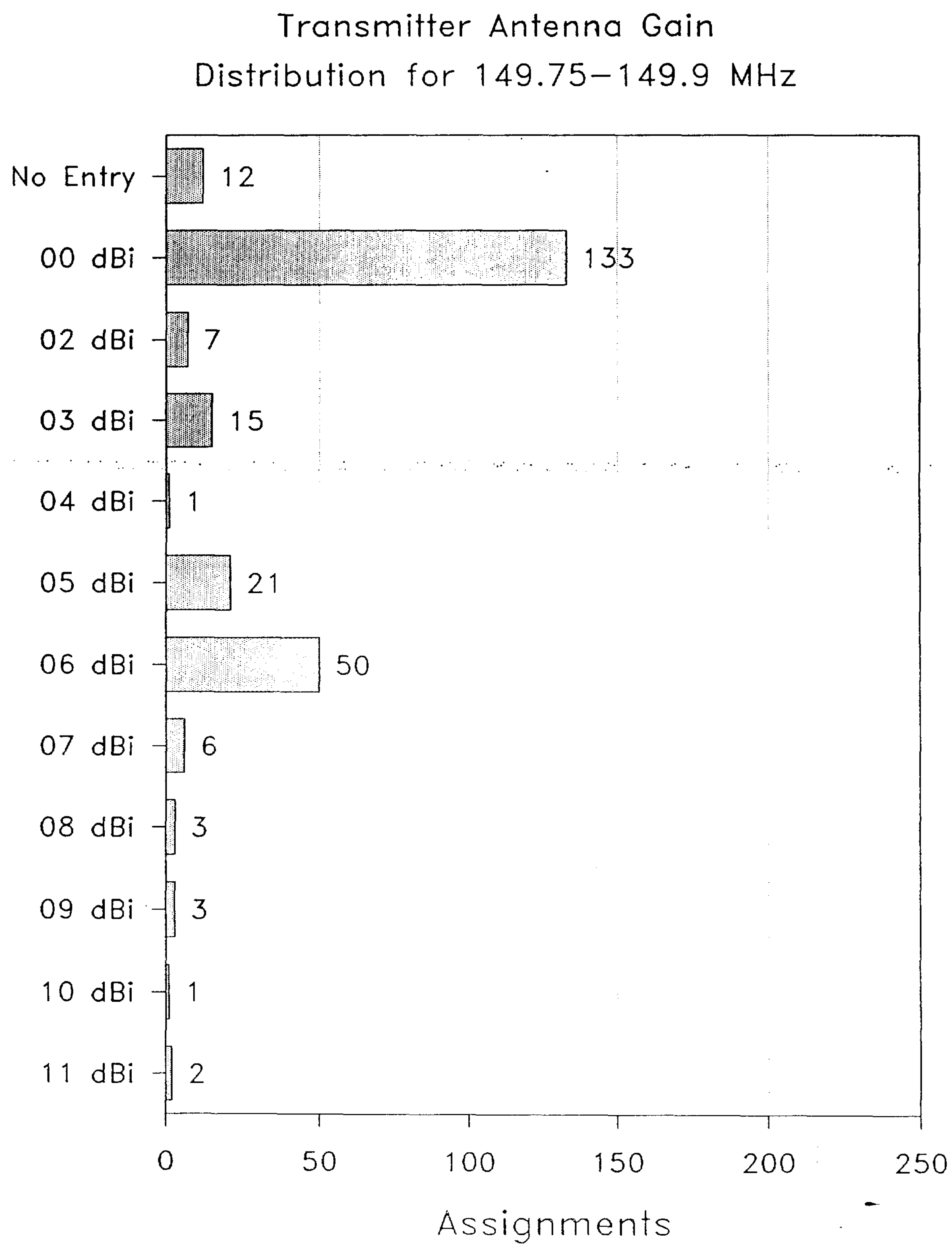

Transmitter Antenna Gain
Distribution for 149-149.25 MHz
No Entry
00 dBi
01 dBi
02 dBi
03 dBi
04 dBi
05 dBi
06 dBi
07 dBi
09 dBi
10 dBi
11 dBi
12 dBi
16 dBi
22 dBi
104
112
11
4
74
2
45
125
5
2
31
5
8
1
12
0
50
100
150
200
250
Assignments

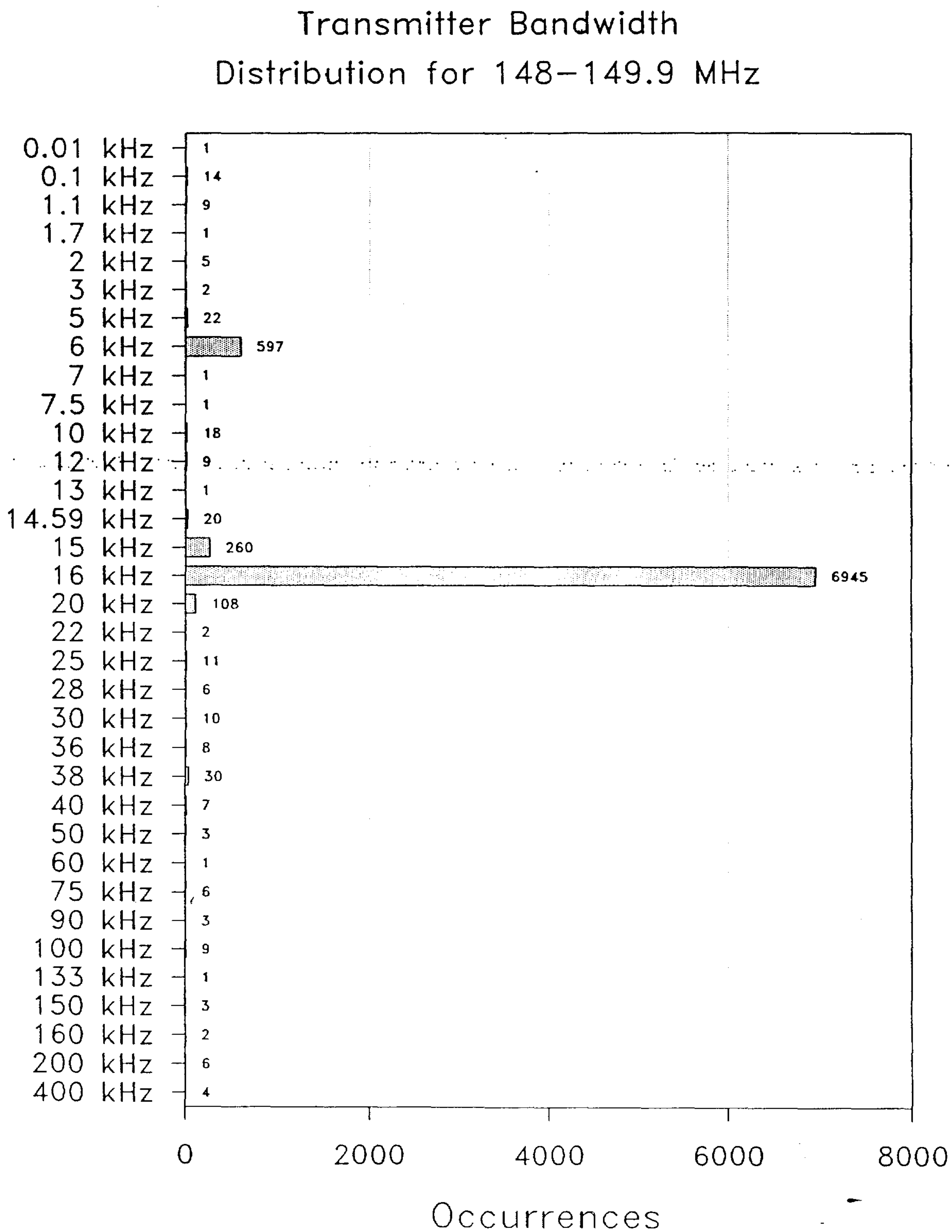
Transmitter Antenna Gain
Distribution for 149.25–149.5 MHz



Transmitter Antenna Gain
Distribution for 149.5-149.75 MHz




Transmitter Antenna Gain
Distribution for 149.75–149.9 MHz
No Entry
00 dBi
02 dBi
03 dBi
04 dBi
05 dBi
06 dBi
07 dBi
08 dBi
09 dBi
10 dBi
11 dBi
12
133
7
15
1
21
50
6
3
3
1
2
0
50
100
150
200
250
Assignments


Transmitter Bandwidth
Distribution for 148–149.9 MHz
0.01 kHz 1
0.1 kHz 14
1.1 kHz 9
1.7 kHz 1
2 kHz 5
3 kHz 2
5 kHz 22
6 kHz 597
7 kHz 1
7.5 kHz 1
10 kHz 18
12 kHz 9
13 kHz 1
14.59 kHz 20
15 kHz 260
16 kHz 6945
20 kHz 108
22 kHz 2
25 kHz 11
28 kHz 6
30 kHz 10
36 kHz 8
38 kHz 30
40 kHz 7
50 kHz 3
60 kHz 1
75 kHz 6
90 kHz 3
100 kHz 9
133 kHz 1
150 kHz 3
160 kHz 2
200 kHz 6
400 kHz 4
0
2000
4000
6000
8000
Occurrences

LEOAC-10

EXTRACT

Telesat

DOC's LEO Spectrum Sharing Study
Phase 2
(Final Report)

January 21, 1992

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TASK 2

Interference from ORBCOMM Terminals into Existing Services

The interfering scenario in this case can be described as a victim receiver surrounded by a number of ORBCOMM terminals. The aggregate interference level received by the victim receiver is a function of the distance between it and the ORBCOMM terminal, the number and the on-off duty cycle of the ORBCOMM terminals. ORBCOMM co-channel operation is also assumed.

In this analysis, the following parameters were assumed:

Frequency	=	149 MHz
EIRP of Transmitter	=	9 dBW
Height of Transmitter	=	1 m
Height of Receiver	=	10 m
Gain of Receive Antenna	=	2 (3 dBi)
ORBCOMM BW	=	4 kHz
ORBCOMM on-off cycle		< 1%(so that Poisson Distribution can be applied)

A program was developed to calculate the probability density function(PDF) that a given co-channel interference level would be exceeded. The results indicate that the probability of interference is below the required 1%, if the interference threshold level is greater than approximately -153 $dBW/m^2/4kHz$. A CCIR new draft recommendation(Doc. USSG 8D-12 Rev. -1, August 2, 1991) by the study group US 8D, states that the protection criteria used in the United States range from -150 to -128 $dBW/m^2/4kHz$. This shows that the interference into existing systems from ORBCOMM terminals should not be a problem. Furthermore, ORBCOMM terminals terminals would normally operate with a certain offset from the centre frequency of existing services, thus the interference probability would be even less than that of the co-channel case.

Interference from Paging Services into ORBCOMM Terminals

The interference scenario in this case can be described by existing paging services, located in the same frequency band as ORBCOMM terminals, transmitting and therefore producing interference at the ORBCOMM satellite. The amount of interference is a function of the number of pagers and their frequency separation from the ORBCOMM terminals. There are over 750 paging services in the 148 to 149.9 MHz band in Canada. A suitable slot where there is sufficient frequency separation between them must be found in order to reduce interference to acceptable levels.

The C/I levels for ORBCOMM mobile transmissions have been calculated using a method similar to the one described in the Draft New Report, Frequency Criteria for Low Earth Orbiting Mobile Satellite System using VHF Spectrum. The adjacent channel isolation was calculated using a triangular spectrum for the pager base stations.

For each of the paging frequencies in Canada, the required frequency separation was calculated, taking into account the number of pagers at that frequency and the maximum Doppler shift, in order that an acceptable C/I ratio be met. The results show that the required frequency separation ranges from 11.81 kHz to 15.58 kHz with the number of pagers 1 and 326 respectively. The slots between pager frequencies are at least 15,30, or 45 kHz wide. In order for the required C/I ratio to be met, the ORBCOMM mobile must be put in the middle of two pager frequencies separated by about 30 kHz. There are a number of these slots available, however, these frequency assignments only include existing pagers. Other services may also be assigned in these slots which would reduce the chance that ORBCOMM can find an empty slot for its transmission.

Interference from STARNET Terminals into Existing Services

The interfering scenario in this case is similar to the one with ORBCOMM terminals. A victim receiver is surrounded by a number of STARNET terminals. The aggregate interference level received by the victim is a function of the distance between it and the STARNET terminal, the number and the on-off duty cycle of the STARNET terminals.

Interference levels will be reduced in this case due to the reduced EIRP of the terminals and the wider bandwidth. Based on the results from the ORBCOMM terminals, the interference levels should be lower and therefore interference from STARNET terminals will be insignificant.

Interference from Existing Services into STARNET

Interference in this case is due to the existing services (ie. pagers), in the same frequency band, transmitting and reducing the STARNET receive margin. The level of the interference will depend upon the number of pagers.

The STARNET system is composed of four gateways and twelve simultaneous users in a 1 MHz bandwidth. The receive margins are calculated based on interference from other users, other gateways, and from the pagers. If there are no pagers present then the resulting margins are 5.09 dB and 2.88 dB for the forward and return links respectively. In Canada there are approximately 308 paging systems in the 1 MHz band between 148 and 149 MHz. Including the interference from these pagers produces margins of -18.86 dB and -21.42 for the forward and return margins respectively. This indicates that sharing would not be possible. The possibility of sharing is borderline even if there is only one paging system. The margins in this case are 2.53 dB and 0.16 dB.

It appears that sharing would not be possible between the STARNET system and the existing pagers in the 148 to 149.9 MHz band. This excludes any services in the same band other than pagers, which will also reduce STARNET's receive margins even further.

CHAPTER 3

LEO BELOW 1 GHz

In this chapter, frequency sharing between LEOs below 1GHz with existing fixed and mobile services is addressed. Two LEO systems below 1GHz are chosen for the analysis. These systems are ORBCOMM which uses FDMA and STARNET which uses CDMA.

3.1 ORBCOMM

3.1.1 Interference from ORBCOMM Terminals Into Existing Services

The interfering scenario in this case can be described as: a victim receiver (a mobile terminal or base station in the mobile services, or a fixed station) is surrounded by a number of ORBCOMM terminals. The aggregate interference level received by the victim receiver is a function of the distance between it and the ORBCOMM terminal, the number and the on-off duty cycle of ORBCOMM terminals. ORBCOMM co-channel operation with the existing services is also assumed.

The interference level received from one transmitting ORBCOMM terminal having isotropic antenna located at d_1 km away is given by:

$$I_1 = EIRP_{tx} x G_{rx} x L_p \tag{1}$$

where:

	$EIRP_{tx}$	is the ORBCOMM terminal transmit EIRP expressed in watts.
	G_{rx}	is the antenna gain of the victim receiver in the direction of the ORBCOMM terminal (numeric).
	L_p	is the path loss between the victim and the interferor (numeric).

The path loss L_p is given by

$$L_p = \frac{88^2 \text{ x } (H_{tx} x H_{rx})^2 \text{ x } 10^{-12}}{(300/f)^2 \text{ x} 120\pi x d_1{}^4} \tag{2}$$

where H_{tx} is the antenna height of the transmitter in meters.

H_{rx} is the antenna height of the receiver in meters.

f is the frequency in MHz.

Equation (2) is derived from the model for the field strength for VHF frequencies in CCIR recommendation 529.

With the following parameters assumed for this analysis:

f	= 149 MHz,
$EIRP_{tx}$	= 9 dBW,
H_{tx}	= 1 m,
H_{rx}	= 10 m,
G_{rx}	= 2 (3 dBi)
ORBCOMM BW	= 4 kHz
ORBCOMM on-off cycle	< 1% (so that the Poisson Distribution can be applied)

then the interference level I_1, in watts/4kHz, can be rewritten as:

$$I_1 = \frac{8.03 \times 10^{-9}}{d_1^4} \tag{3}$$

If there is a second ORBCOMM terminal, located d_2 km away transmits at the same time with the first one, then the interference level under the condition that there are two active interferers is given by:

$$I_2 = \frac{8.03 \times 10^{-9}}{d_1^4} + \frac{8.03 \times 10^{-9}}{d_2^4} \tag{4}$$

Similarly, the interference level given that there are n active interferers is:

$$I_n = \sum_{i=1}^{n} \frac{8.03 \times 10^{-9}}{d_i^4} \tag{5}$$

Since the distance from the interferor to the victim receiver, d_i , is a random variable, thus the interference level I_n is also a random variable.

Assume that the distance d from the interferor to the victim receiver is uniformly distributed between d_{min} and d_{max}, where d_{min} is a few meters and d_{max} is large enough so that the interference level is negligible. It should be noted that the choice of d_{max} should not affect the result of the analysis. However, to limit the required computation, d_{max} should be reasonably small, a value of 94.67 km is used in this analysis which gives a corresponding (minimum) single entry interference level of -160 dBW/4kHz. The probability density function of finding an ORBCOMM mobile within d km away from the victim receiver is a linear function of d and is given by the expression below (follow equation 4-22 Papoulis, Probability, Random Variables and Stochastic Processes, 1965, page 95)

$$f_D(d) = \lim \frac{\text{Prob}\{ d \leq \text{distance} \leq d+\Delta d \}}{\Delta d} \text{ as } \Delta d \text{ approaches } 0$$

$$= \lim \frac{(d+\Delta d)^2 - d^2}{d_{max}{}^2 \times \Delta d} \text{ as } \Delta d \text{ approaches } 0$$

$$= \frac{2d}{d_{max}{}^2} \qquad (6)$$

The probability density function of I_1 is then given by (see equation 5-6, Papoulis, page 126):

$$f_{I_1}(I) = \frac{f_D(d)}{\left| \frac{\delta I_1}{\delta d} \right|} = \frac{4.4805 \times 10^{-5} \times I^{-1.5}}{d_{max}{}^2} \qquad (7)$$

where $\frac{\delta I_1}{\delta d}$ is the derivative of I_1 with respect to d

Since the distances from each of the interferors to the victim receiver are independent random variables, thus the probability density function of I_n can be computed by convolving $f_{I_1}(I)$ by itself n times (see equation 7-7, Papoulis, page 189):

$$f_{I_n}(I) = f_{I_1}(I) * \ldots (\text{n times}) \ldots * f_{I_1}(I) \qquad (8)$$

where * denotes convolution.

Equation (8) gives the conditional probability density function of the interference level. The condition in this case is that there are exactly n active interferers. The probability that there are exactly n interferers, P(n), where n = 0, 1, 2, ..., can be computed by Poisson distribution with the expected arrival rate, λ, determined by ORBCOMM's average channel loading of 30%, the size of ORBCOMM's coverage area of radius 2500 km, and the size of the area of radius d_{max}=94.67 km surrounding the victim receiver.

$$P(n) = \frac{\lambda^n}{n!} e^{-\lambda} \tag{9}$$

where $\lambda = 50x0.3x(d_{max}/2500)^2 = 0.02151$. The factor 50 represents the assumed peak to average factor of the geographical distribution of the ORBCOMM terminals, which is equivalent to the assumption that all ORBCOMM terminals that generate the 30% channel loading are concentrated in about 12 dispersed (populated) areas of d_{max} in radius. This is a very pessimistic assumption considering the fact that there are many metropolitan areas in North America.

Finally, the probability density function of the interference from ORBCOMM terminals into a terrestrial receiver is computed by (see equation 2-33, Papoulis, 1965, page 37)

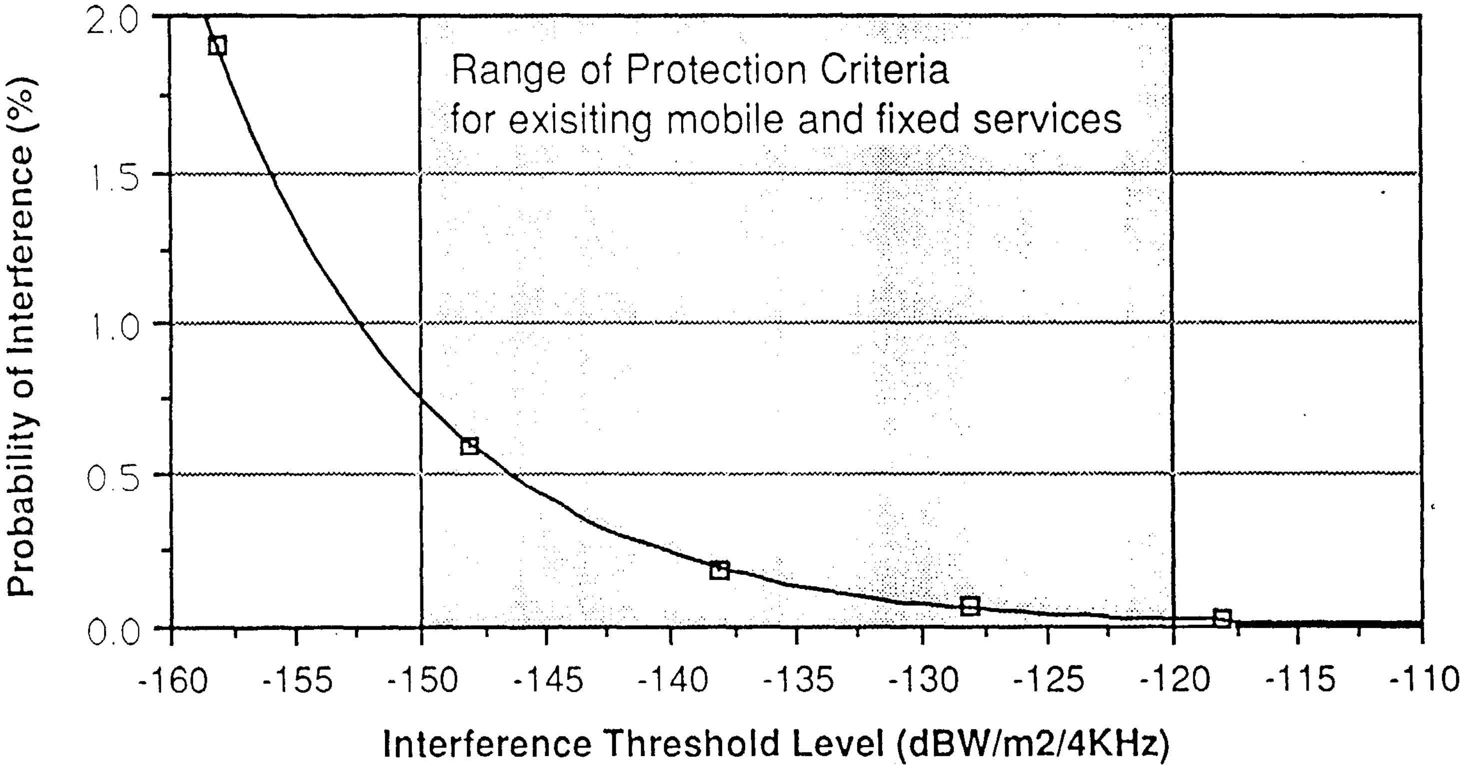
$$f_I(I) = \sum_{n=0}^{\infty} P(n) f_{I_n}(I) \tag{10}$$

The probability that the interference level exceeds a threshold level, I_t(dBW/4kHz), is then given by.

$$\mathrm{Prob}(I > I_t) = 1 - \int_0^{I_t} f_I(I) \; dI \tag{11}$$

A program has been written to perform the calculations of equation (11) and a graph of the final results is shown in Figure 3.1. A CCIR new draft recommendation(Doc. No. USSG 8D-12 Rev. -1, August 2. 1991), by the study group US 8D, states that protection criteria used in the United States ranges from -150 to -128 dBW/m²/4kHz.

Figure 3.1: Probability of Interference from ORBCOMM Terminals to Existing Services



As shown in Figure 3.1, the probability of interference is less than the required 1% in this range, indicating that interference into existing systems from ORBCOMM terminals should not be a problem. These results are the same no matter what the maximum distance, d_{max}, is taken to be.

3.1.2 Interference from Paging Services into ORBCOMM Terminals

The interference scenario in this case can be described by existing paging services, located in the same frequency band as the ORBCOMM terminals, transmitting and therefore producing interference at the ORBCOMM satellite. The amount of interference is a function of the number of pagers and their frequency separation from the ORBCOMM terminals. In Canada, there are over 750 paging services in the 148 to 149.9 MHz band. A suitable slot where there is sufficient frequency separation between them must be found in order for acceptable interference to exist.

The C/I levels for ORBCOMM mobile transmissions have been calculated as shown below.

Mobile Terminal:

Transmission Power	7.0 dBW
Antenna Gain/Loss	2.0 dB
EIRP	9.0 dBW
Free Space Loss(5 Deg. Elevation)	-145.7 dB
Atmospheric Loss	-3.2 dB
Polarization Loss	-3.0 dB
Isotropic Signal Level at the MSS Satellite	-142.9 dBW

Base Station:

EIRP	21.0 dBW
Free Space Loss(5 Deg. Elevation)	-145.7 dB
Atmospheric Loss	-3.2 dB
Polarization Loss	-3.0 dB
Isotropic Signal Level at the MSS Satellite	-130.9 dBW

C/I Calculation:

Base Station Isotropic Signal Level at Satellite	-130.9 dBW
Adjacent Channel Isolation(I_s)	22.4 dB

Signal Level in MSS Channel from BS	-153.3 dBW
MSS Earth Terminal Signal Level at Satellite	-142.9 dBW
C / I	10.4 dB

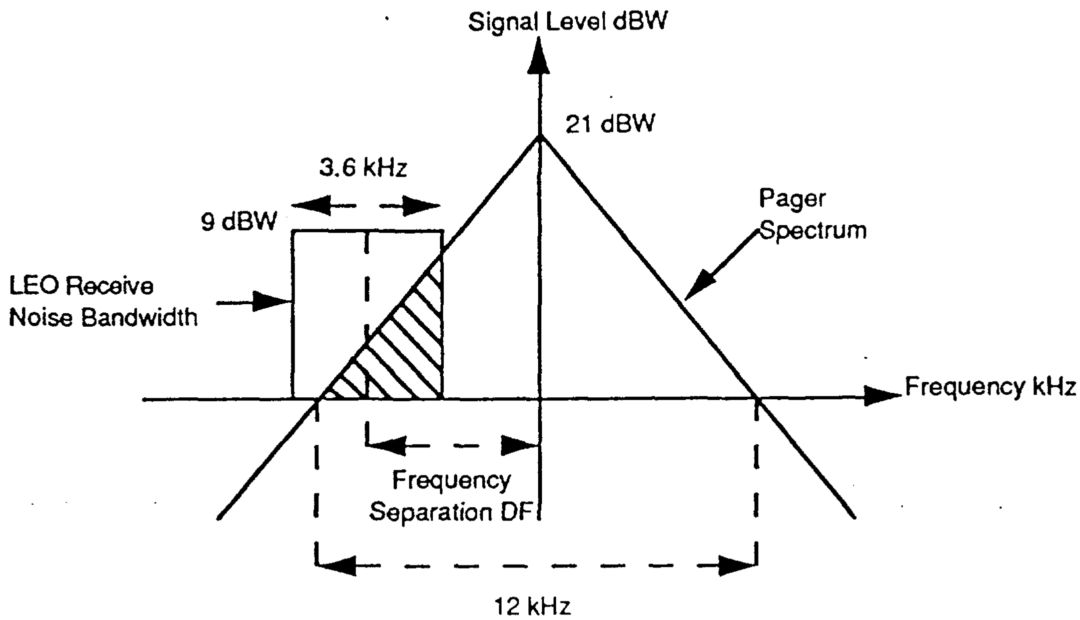


Figure 3.2 : Pager Spectrum and LEO Receive Noise Bandwidth

The Adjacent Channel Isolation, Is, was calculated in the above example using a frequency separation, between the pager and ORBCOMM mobile, of 4.7 kHz. This separation is given by the difference between half of the nominal pager frequency separation(15 kHz) and the Doppler shift(2.8 kHz). The adjacent channel isolation is determined in the following manner. A triangular spectrum was assumed for the pager base stations. Figure 3.2 illustrates this spectrum along with the receive noise bandwidth of the mobile terminals. The frequency separation is given by the separation from the centre frequency to centre frequency. The isolation is given by the ratio of the area overlapping between the mobile's channel noise bandwidth and the pager spectrum (shaded area), and the total area under the pager spectrum. If the area under the pager spectrum was normalized to unity power then the shaded area becomes the isolation value.

The first two columns of Table 3.1 illustrate the distribution of the pager terminals with respect to their frequencies between 149.0 and 149.9 MHz in Canada. The distribution of the pagers are concentrated among the major metropolitan centres, and due to the geographical location of major Canadian centres and the large coverage of an ORBCOMM satellite, at some instance of time, the satellite will be inside the mainlobe of <u>most</u> of these paging transmitters. Figure 3.3 shows an example of such a geometrical arrangement.

For each of the paging frequencies in Table 3.1, the required frequency separation was calculated in order that an acceptable C/I ratio be met. This is calculated as follows. The C/N for the uplink of the mobiles is given as 28.6 dB. Using I as 10% of the noise N, the required C/I can be calculated to be 38.6 dB. The number of pagers at a certain frequency will increase the power by n times, since there would be little discrimination of the pager antenna towards the satellite as discussed above, where n is the number of pagers. Therefore the single-entry interference level will be increased by 10 log(n). Using the formula for adjacent channel isolation and solving for the frequency separation, we can find the required frequency separation to meet the required C/I ratio. This calculation is given by:

Equation for the right side of the spectrum in Figure 3.2 is given by:

$$p = a - \frac{40}{6} f \quad [\mathrm{dBW}]$$

where	p	is the signal level of the pager transmitter
	a	is the y intercept
	$\frac{40}{6}$	is calculated based on an assumption that the spectrum is 40 dB lower at the edge of the 12 kHz bandwidth
	f	is the separation from the centre frequency(kHz)

In numerical form,

$$p = 10^{(a - \frac{40}{6} f)/10}$$

A maximum limit of 15 kHz has been set on the pager spectrum since contribution at frequencies farther than 15 kHz should be negligible. Therefore, a can be calculated by

	Mobile Terminal	Base Station
Tx Power	7.00	11.00
Antenna Gain/Loss	2.00	10.00
EIRP	9.00	21.00
Free Space Loss	-145.70	-145.70
Atmospheric Loss	-3.20	-3.20
Polarization Loss	-3.00	-3.00
Signal Level at Sat.	-142.90	-130.90

Frequency (MHz)	149.00
C/I without Isolation (dB)	-12.00
Required C/I (dB)	38.60
Required Isolation (dB)	50.60
Maximum Doppler Shift (kHz)	2.87
Carson Bandwidth Measured at (dB)	-40.00
Y Intercept (dBw)	-1.15

Frequency(MHz)	Number of Pagers	Required Isolation with # pagers	Isolation(Num)	Required Frequency Separation with Doppler Shift(kHz)
148.045	8	59.63	1.0887E-06	13.16
148.075	31	65.51	2.80956E-07	14.04
148.105	15	62.36	5.80642E-07	13.57
148.120	3	55.37	2.90321E-06	12.52
148.165	24	64.40	3.62901E-07	13.88
148.180	4	56.62	2.17741E-06	12.71
148.225	3	55.37	2.90321E-06	12.52
148.240	8	59.63	1.0887E-06	13.16
148.255	11	61.01	7.91785E-07	13.37
148.270	13	61.74	6.69972E-07	13.48
148.285	7	59.05	1.24423E-06	13.07
148.315	28	65.07	3.11058E-07	13.98
148.330	16	62.64	5.44352E-07	13.61
148.345	1	50.60	8.70964E-06	11.81
148.375	3	55.37	2.90321E-06	12.52
148.390	1	50.60	8.70964E-06	11.81
148.405	23	64.22	3.7868E-07	13.85
148.420	4	56.62	2.17741E-06	12.71
148.435	4	56.62	2.17741E-06	12.71
148.510	8	59.63	1.0887E-06	13.16
148.540	1	50.60	8.70964E-06	11.81
148.555	26	64.75	3.34986E-07	13.93
148.615	7	59.05	1.24423E-06	13.07
148.735	3	55.37	2.90321E-06	12.52
148.765	18	63.15	4.83869E-07	13.69
148.795	38	66.40	2.29201E-07	14.18
149.020	12	61.39	7.25803E-07	13.43
149.050	1	50.60	8.70964E-06	11.81
149.110	1	50.60	8.70964E-06	11.81
149.125	1	50.60	8.70964E-06	11.81
149.140	1	50.60	8.70964E-06	11.81
149.185	3	55.37	2.90321E-06	12.52
149.230	6	58.38	1.45161E-06	12.97
149.260	10	60.60	8.70964E-07	13.31
149.305	2	53.61	4.35482E-06	12.26
149.380	30	65.37	2.90321E-07	14.02
149.395	2	53.61	4.35482E-06	12.26
149.470	2	53.61	4.35482E-06	12.26
149.500	2	53.61	4.35482E-06	12.26
149.665	26	64.75	3.34986E-07	13.93
149.680	3	55.37	2.90321E-06	12.52
149.769	2	53.61	4.35482E-06	12.26
149.770	326	75.73	2.67167E-08	15.58
149.815	1	50.60	8.70964E-06	11.81
149.830	2	53.61	4.35482E-06	12.26
149.860	3	55.37	2.90321E-06	12.52
149.875	13	61.74	6.69972E-07	13.48
149.890	2	53.61	4.35482E-06	12.26
Total	759			

Table 3.1 Required Frequency Separation

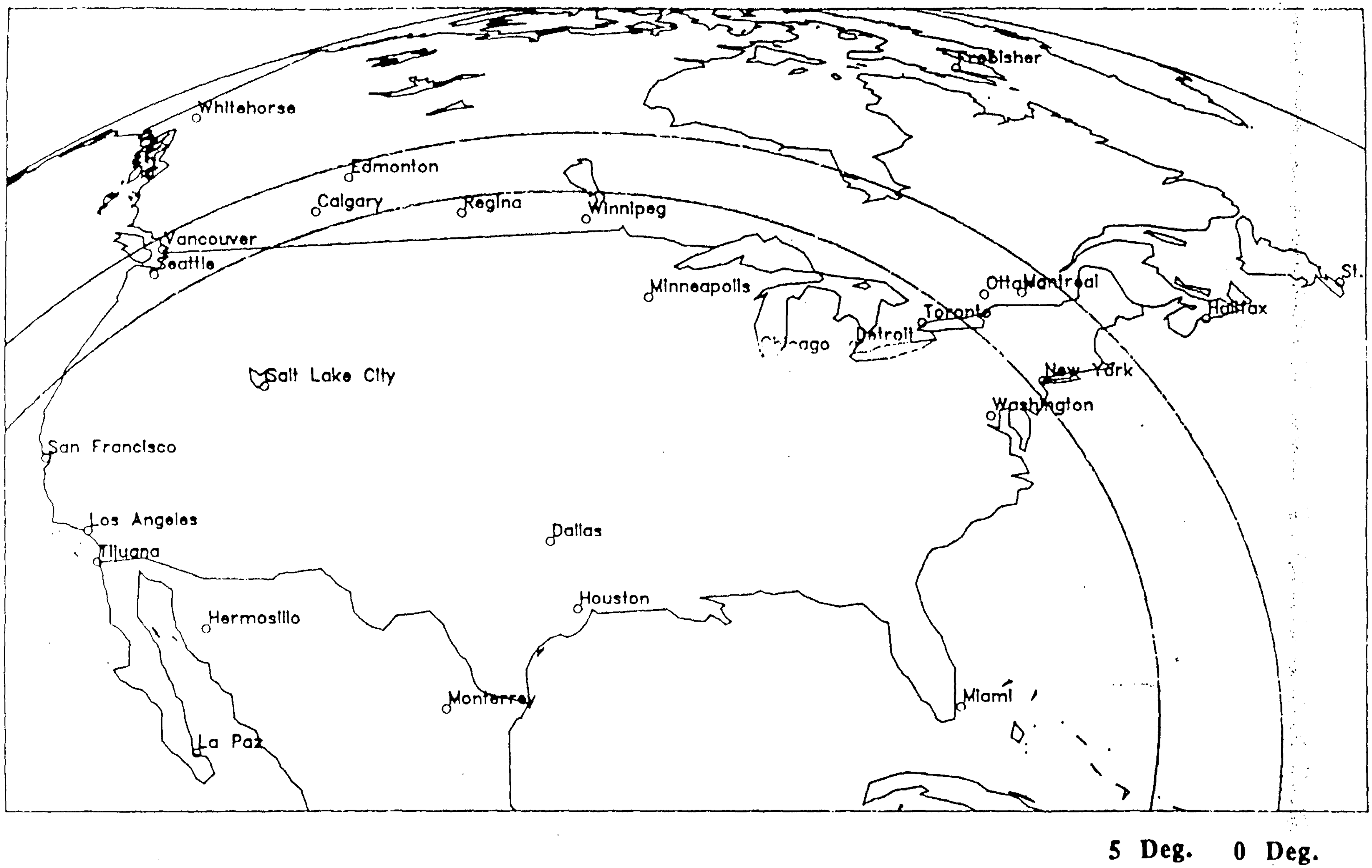


Figure 3.3: **Footprint of 0 and 5 Degree Elevation Contours from ORBCOMM Satellite**

integrating p from 0 to 15 and setting that equal to 0.5, since we want the spectrum normalized to unity power. The y-intercept a is then given by:

$$a = 10 \times \log\left(-0.019188 \times \frac{40}{(10^{-40 \times 15/60} - 1)} \right) = -1.15$$

The shaded area can then be calculated as follows:

$$Is = \text{Shaded Area} = \int_{Df-1.8}^{Df+1.8} 10^{(a-(\frac{40}{6})f)/10}\, df$$

where: Df = frequency separation of mobile from pager(kHz)
1.8 = half the bandwidth of the mobile spectrum(kHz)

Solving for Df gives:

$$Df = \frac{60}{40} \times \log\left(\frac{10^{a/10} \times (1-10^{1.8 \times 40/30})}{-40/60 \times \ln(10) \times 10^{Is/10} \times 10^{1.8 \times 40/60}}\right)$$

where Is = adjacent channel Isolation in dB

The Doppler shift must also be taken into account. The maximum Doppler shift occurs at an elevation angle of 5 Degrees. The Doppler shift, Δf, is calculated as shown below.

$$\Delta f = \frac{s}{c}\ f \cos(\theta) \qquad [\mathrm{Hz}]$$

Where: s = speed of satellite (400 Km/minute = 6666.67 m/s)
c = speed of light(3×10^8 m/s)
f = frequency in Hz

s $\cos(\theta)$ is the component of the satellite velocity in the mobile to satellite direction with θ = 29.88 degrees for a 5 degree elevation. For a frequency of 149 MHz, the Doppler shift, Δf = 2.87 kHz.

The Doppler shift is added to the required frequency separation, Df, to give the total frequency separation required to meet the required C/I ratio. Ignoring the frequency instability of the paging transmitters, the results of these calculations for each of the frequencies are shown in Table 3.1.

Table 3.1 illustrates that the required frequency separation including the Doppler shift ranges from 11.81 kHz to 15.58 kHz with the number of pagers 1 and 326 respectively. The slots between pager frequencies are at least 15, 30, or 45 kHz wide. In order for the required C/I ratio to be met, the ORBCOMM mobile must be put in the middle of two pager frequencies separated by about 30 kHz.

There are a number of these slots available for the ORBCOMM mobiles. However, these frequency assignments only include existing pagers in this frequency range. Other services may also be assigned in these slots which would reduce the chance that ORBCOMM can find an empty slot for its transmission. Normally, ORBCOMM would operate with a certain frequency offset and the interference probability would be less than the co-channel case.

3.2 STARNET

3.2.1 Interference from STARNET Terminals into Existing Services

The interfering scenario in this case is similar to the one described in Section 3.1.1, ORBCOMM Terminals interfering with Existing Services. A victim receiver is surrounded by a number of STARNET terminals. The aggregate interference level received by the victim is also a function of the distance between it and the STARNET terminal, the number and the on-off duty cycle of the STARNET terminals.

In this case, the EIRP of the STARNET terminals is significantly lower than the ORBCOMM terminals. An EIRP of 2.98 dBW as opposed to 9.0 dBW. Another factor contributing to a lower interference level is the bandwidth used. The interference level in the case of the ORBCOMM terminals was calculated over a bandwidth of 4 kHz. The STARNET terminals use spread spectrum modulation and will spread their signal power over a bandwidth of 1 MHz. This will reduce the interference levels seen by the victim receiver by 24 dB, which is significant.

Based on the results of the probability of interference for the ORBCOMM terminals in Section 3.1.1, having lower levels of interference for STARNET terminals will certainly reduce the probability of interference. Interference from STARNET terminals will be insignificant.

3.2.2 Interference from Existing Services into STARNET

Interference in this case is due to the Existing Service (ie. Pagers), in the same frequency band, transmitting and reducing the STARNET receive margin. The level of the interference will depend upon the number of pagers.

The STARNET system is comprised of four gateways and twelve simultaneous users in a 1 MHz bandwidth. This configuration is shown in Figure 3.4. The forward and return link budgets are calculated and shown in Table 3.2. These calculations include the interference from thermal noise, other users, and other gateways.

In the case of the forward uplink, the carrier to noise density resulting from considering the thermal noise, $(\frac{C}{N_0})_{Thermal}$, is 64.0 dBHz. The interference from the users may be calculated as follows.

$$(\frac{C}{I_0})_{User} = \text{Gateway EIRP - Total EIRP density of other users}$$
$$= 8.55 - (2.98 + 10 \log(12) - 10 \log(1 \text{ MHz}))$$
$$= 54.78 \text{ dBHz}$$

This same link will also have interference from the other three gateways. The gateway interference is calculated as follows.

$$(\frac{C}{I_0})_{Gateway} = \text{Gateway EIRP -(Total EIRP density of other 3 Gateways)}$$
$$= 8.55 - (8.55 + 10 \log(3) - 10 \log(1 \text{ MHz}))$$
$$= 55.23 \text{ dBHz}$$

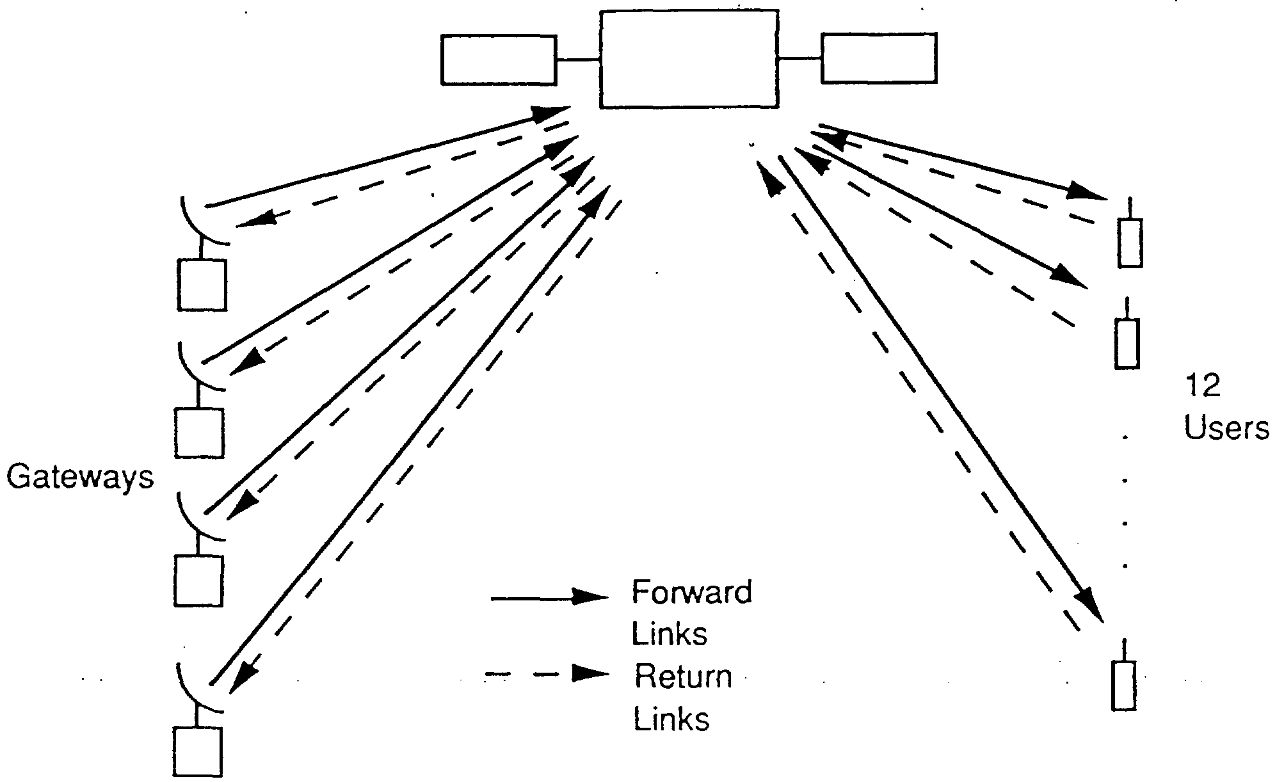


Figure 3.4: STARNET System Configuration

Bandwidth (MHz)	1.00
10log(Bandwidth)	60.00
Simult. Users	12.00
Forward Channels	4.00
Number of Pagers	0.00
EIRP of Pagers (dBW)	21.00
Required Eb/No	2.30

	FORWARD		RETURN	
	UP	DOWN	UP	DOWN
Transmit Power (Watts)	0.18	1.20	2.50	0.30
Gain of Tx Ant (dBi)	16.00	2.50	-1.00	3.00
EIRP	8.55	3.29	2.98	-2.23
Ls(dB)	147.37	146.76	147.37	146.76
Lp(dB)	2.00	2.00	2.00	2.00
Lr(dB)	0.50	2.00	0.50	2.00
Gain of Rx Ant(dB)	3.00	1.00	3.00	16.00
Carrier (dBW)	-138.32	-146.47	-143.89	-136.99
Ts (K)	425.00	500.00	425.00	300.00
Gr/Ts (dB/K)	-23.28	-25.99	-23.28	-8.77
C/No (dBHz)	64.00	55.14	58.43	66.84
Rb (b/s)	8334.00	8334.00	4167.00	4167.00
Eb/No (dB)	24.79	15.93	22.23	30.64
(C/No)Thermal	64.00	55.14	58.43	66.84
(C/No)User	54.78	49.59	49.59	43.69
(C/No)Gateway	55.23	59.50	48.41	55.23
(C/No)External	100.00	100.00	100.00	100.00
Composite Up&Down	51.72	48.19	45.71	43.37
Forward & Return	46.59		41.38	
Required Eb/No	2.30		2.30	
(C/No)Reqd	41.51		38.50	
MARGIN	5.09		2.88	

Table 3.2: CDMA Interference - 0 Pagers